# Integrated core-edge-wall simulations using FACETS

JR Cary[1*] for the FACETS Team[2]

[1] *Tech-X Corporation, Boulder CO 80303 and the University of Colorado, Boulder CO 80309, USA*
[2] *JR Cary, A Hakim, SE Kruger, JA Carlsson, M Miah, A Pankin, A Pletzer, S Shasharina, S Vadlamani (Tech-X); L Mc Innes, S Farley, M McCourt, H Zhang (Argonne NL); R Groebner (General Atomics); RH Cohen, T Rognlien, T Epperly (LLNL); J Cobb (ORNL), N Dexter (U Tennessee) W Spear (Paratools); A Pigarov (UC San Diego)*
** Email: cary@txcorp.com*

It is well recognized that the plasma edge has a strong influence over the core fusion performance as well as plasma/wall interactions. Whole device modeling requires inclusion of edge modeling. However, the different regions (core and edge) require different approximations to the underlying physical modeling. The core can be modeled by a one-dimensional transport equation while the edge is minimally modeled by a two-dimensional transport equation. To advance the modeling of the coupled system, one can either try to generalize the methods of one region to extend into the other, or one must take an approach that allows for the coupling of computational components of differing dimensionalities and internal algorithms.

FACETS has taken the second approach, commonly referred to as a component approach. Standard approximations are used in each region. The components are connected at a location where both approximations are valid, i.e., at a place where the plasma parameters have essentially become constant on magnetic flux surfaces. This approach has the advantages of separation of concerns. The different components each need minimal information from the other components, and the different regions can be governed by different equations of different dimensionalities and timescales.

From the outset, FACETS is oriented towards parallel computing and implicit coupling. The FACETS framework supports the execution of multiple parallel components by managing the communicators needed by each component. The components can be executed concurrently on separate communicators or sequentially on the same communicator. The FACETS framework has been written generally. In addition to being able to conduct coupled core-edge computations, FACETS can: use parallel embedded turbulence computations to obtain transport fluxes; bring in a model for interaction of species with the wall; and/or incorporate complex sources, such as neutral beams.

In bringing together such a complex computational application, a number of software engineering issues inevitably arise and must be addressed. In particular, with its great complexity (some millions of lines of code are managed by FACETS), it is important that the various components be well tested both standalone and within the framework, as well as in coupled simulations. Additionally, there are complexities in simply building the entire system across its many supported platforms. Finally, there are difficulties in usage, for which client-server approaches are being investigated. Our solutions to these issues will be discussed.

Lastly, we will provide some of FACETS latest physics results, including core-edge simulations using GLF23/UEDGE and comparisons of multiple transport flux models for the pedestal. Comparisons with experimental results will be shown.